OFFSHORE HYDRAULIC FRACTURING

BACKGROUND

Offshore, a form of hydraulic fracturing has been in commercial use since the early 1990's. Similar to hydraulic fracturing that is being used to develop unconventional resources onshore (shale and tight sand), hydraulic fracturing offshore has combined two mature oil and gas technologies – hydraulic fracturing and gravel pack completions[1]. The result has been a significant improvement in well life and reliability, productivity, and oil and gas recovery.

In many offshore regions, the geologic formations that produce oil and gas are unconsolidated, which means the sand that makes up these formations is loose or poorly bonded, much like the sand on a beach. As a result, this loose sand can end up inside the production piping in the well or production equipment on the surface. Sand production is highly undesirable since it can plug pipes and equipment, erode piping (much like sand blasting) and lead to corrosion of pipe and equipment. Eliminating sand production has been one of the main production challenges faced by engineers since the early days of offshore oil and gas development.

HOW IT WORKS

Sand control technologies have evolved and matured over the years, reaching their peak with the development of gravel packing technology in the early 1970's. Installing a gravel pack completion involves using specialized equipment to place what amounts to a sand filter (the same concept as using sand filters for treating drinking water) in the well at the depth of the productive formation to stop the production of sand. Over the years, operators learned that the bigger (thicker) the filter the better the well performed. The desire to create an even bigger "filter" is what led to the combination of hydraulic fracturing and gravel pack completion technologies into what is now called a "Frac Pack" completion.

A conventional gravel pack completion uses relatively small volumes of sand[2], 1,000 to 20,000 pounds of sand is typical, depending on the size of the pipe placed across the productive formation (casing) and the thickness of that formation. Using specialized equipment (packer, cross-over tool, screen, tail-pipe) the sand is pumped into place. Pumping pressures are usually limited so they do not exceed the fracture pressure of the productive formation.

A Frac Pack will use much larger volumes of sand (50,000 to over 250,000 pounds is now common) depending on the thickness of the productive formation. When performing a Frac Pack, pump pressures are intentionally increased by increasing the pump rate to exceed the fracture pressure of the formation and force sand outside the casing and well into the productive formation.

During a Frac Pack the pumping equipment, sand (proppant) and additives are carried, mixed, and pumped from a specialized stimulation and treatment vessel. The base fluid that is used for the Frac Pack operation will typically be treated seawater, although other brines may be used if conditions dictate.

The proppant and other additives are mixed as the Frac Pack is being performed. Since the formations that are being fractured offshore are very permeable (a measure of the ability of fluid to flow through the formation), the fracturing fluid will usually be more viscous and have a higher sand concentration than similar fluids used onshore. In the producing formation, the fracture network that is created can be expected to be less dense and usually will not extend as far from the well since it is far less brittle and more permeable than a shale or tight sand. A thick layer of proppant is placed in the formation, which facilitates the filtering function of the Frac Pack. After the fracturing and proppant placement portion of the operation is completed, a conventional gravel pack can be performed to ensure placement of sand inside the well in the annulus between the casing and the production screen. Multiple productive formations can be Frac Packed in series, further improving operational efficiency and oil and gas recovery.

Additives used in Frac Pack operations are often similar, if not identical, to those used for shale or tight sand development onshore and they are used for similar purposes. The concentrations of some of these additives are typically different due to the very different geologic characteristics of the producing formation, the most significant difference being the much higher formation permeabilities and the lower amounts of clay/shale in those formations. Another factor that can significantly influence additive selection and use in offshore operations is the ability to discharge treated wastewaters that meet applicable regulatory requirements.

[1]For onshore wells it has been the combination of hydraulic fracturing and horizontal drilling that has made production from shale and tight sand formations economically viable.

[2]The sand used for a gravel pack, Frac Pack or onshore hydraulic fracturing is essentially identical, usually natural silica quartz although treated sand or other man-made materials can be used in specialized situations.

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REGULATION

Offshore, the primary regulatory authority is the **Department of Interior's Bureau of Safety and Environmental Enforcement (DOI-BSEE)**. DOI-BSEE is responsible for approving well designs, drilling procedures, well completion plans and procedures and most aspects of production operations. **The Environmental Protection Agency (EPA)** holds responsibility for managing discharges from offshore facilities. Discharges are managed under the **Clean Water Act** and its **National Pollutant Discharge Elimination System (NPDES)** permit program.

The ability to discharge recovered fluids from Frac Pack operations offshore is an important logistical consideration. The NPDES permits issued by the EPA for the offshore oil and gas industry have strict discharge limits and monitoring requirements for many categories of discharges, including "well treatment fluids" and "produced water." Well treatment fluids include fluids recovered from Frac Pack operations and produced water (natural formation water from the producing formation) can include produced water mixed with treatment fluids.

Permit limits applicable to these discharge categories include:

- Prohibition of discharges of listed priority pollutants (other than trace amounts),
- No free oil (no sheen),
- Daily maximum and monthly average limits on the oil content of the discharge,
- Discharge volume reporting, and
- Toxicity limit if the treatment fluid is mixed with produced water.

These performance based limits provide strict controls on the fluids that are discharged and ensure a sound, risk-based approach to protecting the environment.

If the recovered treatment fluid cannot meet the NPDES permit limits, this fluid would be sent to shore for disposal in deep injection wells that are permitted under the **Safe Drinking Water Act** and managed by the respective states where the injection would occur (authority delegated to the state once the state program is found to satisfy federal requirements). The injection wells are operated as **Class II** wells under the EPA's Injection Control Program.

Class II wells are specifically designed to ensure protection of groundwater, isolation of injected fluids, are monitored to ensure the integrity of the well and the geologic formation into which the fluid is injected at all times, and to document the sources and volumes of fluids that are injected.

SUMMARY

Frac Pack operations offshore have a robust record of flawless performance. In the U.S., all oil and gas well completion operations, including Frac Pack are managed by the DOI – BSEE and most environmental issues relevant to Frac Pack are managed by the EPA. The operational and environmental aspects of these operations receive significant scrutiny by these agencies and are supported by strong operational management practices used by operators.